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Testing Methods for Sensor Test and Evaluation Using the DNA Nuclear Infrared Clutter Simulator

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13. ABSTRACT (Maximum 200 words)

The purpose of this interim report is to document methods that have been developed for the test and evaluation of interceptor and surveillance sensor systems using the Defense Nuclear Agency (DNA) Nuclear Infrared Clutter Simulator (NICS) system (Old, 1993). The methods presented here have been developed on DNA contract DNA 001-93-C-0145, Applications of the Nuclear Infrared Clutter Simulator (ANICS) program. The methods have evolved as the result of experience gained over the course of multiple NICS sensor focal plane array (FPA) test campaigns and the subsequent data analysis necessary to evaluate FPA and modeled sensor performance.

Methods documented here are applicable to sensor testing with either the original NICS static display optical configuration or the new dynamic display optical configuration (Old, 1994). The original bench is referred to as the NICS Static Display Bench, while the newest optical bench is referred to as the Dynamic Display Bench. The latter configuration utilizes DNA Nuclear Optical Dynamic Display System (NODDS) technology, which provides the sensor under test with dynamic infrared optical scenarios.

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SUMMARY

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SECTION 1
NICS - NUCLEAR INFRARED CLUTTER SIMULATOR

1.1 NICS SYSTEM OVERVIEW.

The Nuclear Infrared Clutter Simulator (NICS) is a low background infrared imaging system that is currently being operated by Mission Research Corporation for the Defense Nuclear Agency Simulation Technology Division. The NICS is a proven sensor technology testbed that provides the sensor design and development community with the capability of evaluating surveillance and interceptor optical sensor system performance in optically cluttered and ionizing radiation environments (Pritchett, 1994). NICS provides environments that include point source and extended moving targets, background optical clutter, and ionizing radiation. By April 1995, the NICS will be capable of testing sensors with DNA NODDS fully dynamic infrared display imagery (Old, 1994), making it unique in the testing and evaluation community. Over the past three years, the NICS has successfully supported a wide variety of both focal plane and sensor technology development programs such as Theater High Altitude Area Defense (THAAD), USASSDC Pilotline Experimental Technology (PET), Ground-based Surveillance and Tracking Sensor (GSTS), and Brilliant Eyes.

The NICS can provide space level, natural, and nuclear ($>10^{17}$ photons/cm^{2}sec) background irradiances from the short through the long wave infrared spectrums. The scene projection capability consists of static and dynamic infrared displays with collimation and reimaging optics that can be held at liquid nitrogen or lower temperatures. A focal plane test dewar is mounted on the vacuum chamber so that an FPA or sub-module can be illuminated by the infrared (IR) image.

Figure 1-1 is a photograph of the NICS in operational configuration for a sensor FPA test campaign conducted at MRC.

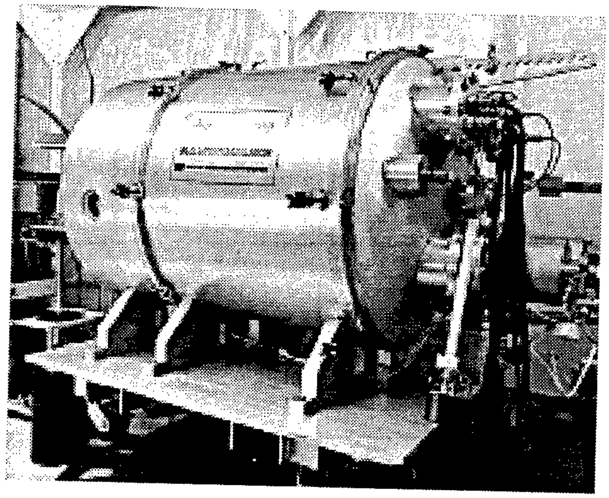

Figure 1-1. The DNA NICS configured for a sensor simulation.

1.2. NICS SYSTEM CAPABILITIES.

There are two optical projectors that comprise the NICS system, the Static Display Optical Bench and the Dynamic Display Optical Bench.

1.2.1 NICS Static Display Optical Bench.

The static bench optics consist of display collimation optics, a scanning mirror in collimated space, and reimaging (sensor) optics that image the displays onto the sensor focal plane array under test. The collimator and reimager are off-axis, reflective, three mirror designs that allow high contrast, achromatic imaging. Both the collimator and reimager were designed and fabricated using principles utilized for various flight qualified sensors and optical instruments.

These systems are nearly diffraction limited from 2 μm to beyond 15 μm. The beam combiners define the optical spectrum available for testing as 2 to 15 μm. The collimator and reimager combine to give a system magnification of 0.2, or 5:1 imaging from the displays to the FPA. An optical background of 10^{10} photons/cm^{2}sec, $\lambda = 10 \pm 0.5$ μm, can be achieved with appropriate cold filtering. Other optical system specifications are given in Table 1-1. Both the collimator and reimager are located in light-shielded boxes with the system stop aperture located in a tube connecting the boxes. The design reduces the risk of off axis sources interfering with low background, space environment LWIR testing.

Table 1-1. NICS optical system parameters.

Optical Parameter	**Values**
Imager F/#	4.0
Imager FOV	> 1.1° x 1.1°
Collimator F/#	20.0
Collimator FOV	> 1.1° x 2.2°
Blur Diameter at 10 μm	100 μm
Blur Diameter at 5 μm	50 μm

The NICS Static Display Bench contains two infrared transparent displays mounted on translation stages that can move the displays around in the optical field of view (FOV). The light from the displays is combined with a beam combiner and projected by the collimator. One display holds a cassette of three nuclear or natural clutter background scene display plates, while the other holds three target and test reticle plates in a cassette. Each display is illuminated by its own blackbody. The display plates have scene or target features replicated onto them from electron beam photolithography generated masks. These masks allow state of the art feature definition down to 0.1 μm, the electron beam limit. NICS static display attributes are given in Table 1-2.

Table 1-2. NICS display attributes.

Display Parameter	**Value**
Clutter Scene Radiance, 8-12 μm	10^{-8} to 10^{-3} W/cm^2/Sr
Target Irradiance, 8-12 μm	2 x 10^{-11} to 10^{-6} W/cm^2 on FPA
Source Nonuniformity at FPA	< 1.4% Across Field
Scene Plate Translation	± 2.2°
Target Plate Translation	± 2.2° in X, ± 2.2° Y
Translation Resolution	30 μm in display plane
Display Angular Velocity	0 - 7.2 mrad/sec
Display Plate Size	6.4 x 6.4 cm

The display blackbodies are Bartell cones with programmable temperature control from the optical bench cryogenic temperature to 800K. The blackbody temperature sensor calibration is traceable to the National Institute of Standards and Technology (NIST) platinum resistor thermometer standard and is absolutely accurate to $\pm$ 2K. Each display has a dedicated filter wheel with eight filter positions.

Both the clutter and target displays are mounted on translation stages to provide scene and target translation, display plate selection, and focusing along the optic axis. The scan mirror scans collimated light from the displays along the x (in scan) direction. The targets can be translated in x, y (cross scan), and z (focus), while the scene can be translated in y and z. Both stages can be programmed to move on external trigger. In past tests, the target stage has been programmed to simulate targets flying in parabolic and other trajectories.

1.2.2 NICS Dynamic Display Optical Bench.

The newest optical system, available in the spring of 1995, incorporates two independent DNA Nuclear Optical Dynamic Display System (NODDS) arrays for fully dynamic scene and target generation (CDR, 1994). This optical bench is shown mounted in the NICS in Figure 1-2. The NODDS displays consist of either 128 x 128 or 512 x 512 individually addressable infrared emitter elements. The 128 displays are currently available for use in sensor simulations. The 512 arrays are expected to be available for NICS simulations in the fall of 1995. The displays provide broadband infrared imagery at up to 200 Hz with peak spectral radiances of 10^{-2} W/cm^2 sr μm. The NODDS displays will support hardware-in-the-loop testing of sensor algorithms. With NODDS, hardware-in-the-loop and transitions from point to extended targets are possible during a single simulation run.

The dynamic bench optics consist of display collimation and reimaging optics that image the displays onto the sensor focal plane array under test. The dynamic display bench collimator and reimager are off-axis, reflective, three mirror designs utilizing the same design and fabrication principles of the static bench optics.

The dynamic display bench optics have a diffraction limited design from 2 μm to beyond 15 μm. The beam combiners will define the optical spectrum available for testing from the short to long infrared spectrums. The dynamic display bench collimator and reimager combine to give a system magnification of 0.5, or 2:1 imaging from the displays to the FPA. Optical backgrounds of 10^{10} photons/cm^{2}sec, $\lambda = 10\pm0.5$ μm, will be achieved in this system with appropriate cold filtering. Other dynamic display optical system specifications are given in Table 1-3.

Table 1-3. NICS Dynamic Display Optical Bench parameters.

Optical Parameter	Values
Imager F/#	4.0
Imager FOV	> 2.2° x 2.2°
Collimator F/#	8.0
Collimator FOV	> 2.2° x 2.2°
Blur Diameter at 10 μm	100 μm
Blur Diameter at 5 μm	50 μm

In addition to the two NODDS displays, the dynamic bench contains a single infrared transparent display mounted on a single axis translation stage that can move the display across the optical field of view. The light from the both the NODDS and the static displays is combined with beam combiners and projected by the collimator. Each static display is illuminated by its own blackbody with an eight position filter wheel. The static display motion allows the display to be fully in or out of the optics field of view.

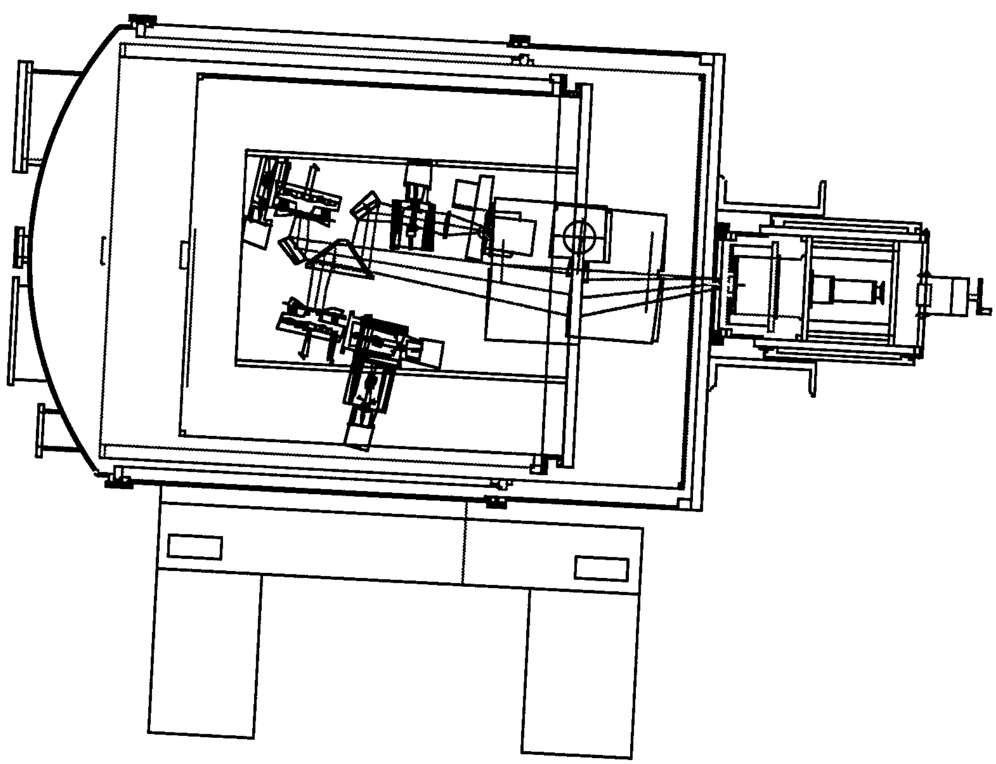

Figure 1-2. Side view of the NICS with the Dynamic Display Optical Bench installed.

1.2.3 NICS Scene Generation.

The NICS projected scenes are generated from code calculations or existing scenes such as those from the Strategic Scene Generation Model or high resolution photography. Scene generation support is provided using automated software to translate a computer stored image to the appropriate format for either the static displays or the NODDS dynamic displays. Thousands of frames can be generated for video scene projection using NODDS. Nuclear scenes are produced with power spectral distributions (PSD) that match the DNA specifications for nuclear clutter.

1.2.4 NICS Sensor Simulations.

The NICS system has supported multiple above ground tests (AGT) operated in gamma, flash x-ray, and neutron radiation testing environments. The system is easily transportable and can be configured and brought to operational status by one technician in one day. In addition to operating in the MRC Radiation Test Laboratory, the NICS has been successfully deployed and operated at several government operated AGT facilities including White Sands Missile Range Gamma Radiation Facility and the Aberdeen Proving Grounds Fast Burst Reactor/Flash X-ray Test Facility. A testing history past and scheduled NICS sensor simulations is given in Table 1-4.

Table 1-4. NICS sensor simulation testing history.

NICS System IOC	August 1992
GSTS Combined Effects Emulation	September 1992
DNA Operate Through Gamma Test at White Sands	March 1993
USASSDC PET FPA Testing	May - July 1993
Brilliant Eyes Sensor Emulation	September 1993
DNA Operate Through FBR/FXR Test at Aberdeen	November 1993
USASSDC PET FPA Testing	July - August 1994
USASSDC THAAD FPA Testing	December 1994
DNA ANICS Interceptor Emulation	April 1995
DNA Sensors Program Testing	July 1995
DNA Sensors Program at Aberdeen	September 1995
USASSDC THAAD Interceptor HWIL Testing	February 1996

1.3. NODDS DYNAMIC DISPLAY OVERVIEW.

The DNA NODDS display development is a collaborative effort between Mission Research Corporation and Honeywell Inc. The NODDS resistor array is an approach to obtaining an IR scene projector capable of wide dynamic range. The emitter array has low thermal conductance to the substrate, which delivers high radiance and requires low power. The array achieves high radiance with high fill factor, high emissivity, and high-temperature (700K) operation.

The 128 x 128 NODDS system is currently available and is being integrated into the NICS in early 1995. A 128 x 128 NODDS array is shown in Figure 1-3. An operational 512 x 512 pixel display will be available by the third quarter of 1995 and should be integrated into NICS by the fourth quarter of 1995. The driver system for the 128 x 128 display operates at a 40 Hz frame rate. The 512 x 512 system will operate at 200 frames per second. The NODDS display system is currently being integrated at MRC.

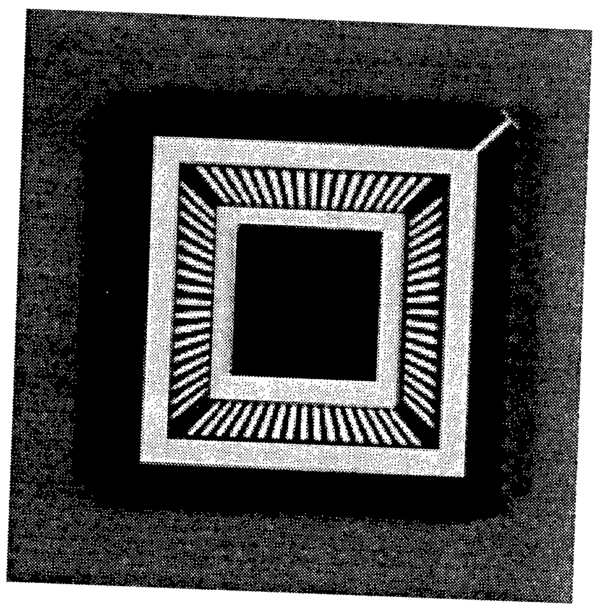

Figure 1-3. NODDS 128 x 128 array in a 68 pin leadless chip carrier.

1.4. NODDS DISPLAY CAPABILITIES.

The 128 x 128 NODDS array has 50 μm x 50 μm pixels with a quarter inch by quarter inch format in 68 pin leadless chip carrier. The 512 x 512 array will be delivered on a custom 3 inch circular daughter board that fits in a Lake Shore MTD 150 cryostat.

Fill factor is achieved with a two-level structure that maximizes the radiating area by placing the pixel drive and addressing electronics directly under the emitting structure. High radiance is achieved by fabricating the pixel with thin absorbing films that have enhanced emissivity when a reflector is placed at the substrate level. The key to low power in the design is to use low thermal conductance materials, most notably Si_3N_4, which are patterned into well-defined shapes, leading to a well-defined thermal conductance path to the substrate.

The low thermal conductance would normally lead to long time constants if not for the fact that the radiating emitter thin films contribute negligible thermal mass. As a typical example, the emitter thermal mass is approximately 10^{-9} J/K for a 2 mil pixel. The thermal conductivity, depending on temperature, is typically in the range of 3×10^{-5} W-μm/K. Thus, a pair of 30 mm long legs will have a thermal conductance of about 10^{-6} W/K.

A 2 mil pixel with 30 μm legs will have an e-folding temperature time constant in the range of 1 ms. The radiance, depending somewhat on wavelength, reaches 90% of the final level within a few thermal time constants. The frame rate of the scenes being projected should be compatible with this pixel thermal time constant.

NODDS array performance characteristics are shown in Table 1-5.

Table 1-5. NODDS display performance characteristics.

Performance Characteristic	Specification
Spectral Range	3 to 12 μm
Max Effective In-band Radiance	10^{-3} W/cm^2 sr
Emission Spectrum	Across spectral range
Radiance Range	10^4
Radiance Resolution	0.1%
End-to-end Radiance Accuracy	1%
Display Background Radiance	< 10^{-8} W/cm^2/sr
Radiance Variation in Frame Time	1%
Pixel-to-pixel Uniformity	0.3% of maximum radiance
Pixel-to-pixel Crosstalk	1%
Spatial Resolution	128 x 128 and 512 x 512
Display Operating Temperature	40K to 273K
Dead Pixels	0.1%
Pixel Fill Factor	15% and 50% arrays
Frame Rate	DC to 200 frames/sec

SECTION 2
METHODS FOR OPTICAL SENSOR SYSTEMS TEST AND EVALUATION

The ultimate objective of optical sensor system test and evaluation is to determine if the subsystem or system under test meets the sensor's mission objectives. The complete optical sensor system typically comprises the sensor focal plane array and its dewar, its associated drive and data capture electronics, signal processors and their algorithms, and the sensor optical imaging system. The NICS simulator is capable of testing any subset of the optical sensor such as its focal plane or its signal processing algorithms only, or the NICS can provide collimated light out of the chamber to test a complete sensor such as an interceptor missile.

An optical sensor test and evaluation campaign should include the following activities: experimental hardware optimization, FPA operation optimization, FPA data acquisition, data processing and analysis, and comparison to expected results. Typically, to achieve the most value per testing dollar spent, data will be acquired under a variety of testing conditions. Test parameters should range from nominal to stressing operating conditions as determined by the candidate sensor's mission objectives and intended operating environments. Data evaluation should take place during the campaign to insure validity and applicability to the specific test objectives. Detailed test data analysis should be conducted after the testing campaign to provide FPA and signal processor characterization results. Finally, the results should be documented and the test data cataloged and stored for future reference. A baseline optical sensor test campaign is shown in Figure 2-1.

2.1 TEST CAMPAIGN CONFIGURATION REQUIREMENTS.

The test campaign experimental hardware must be configured and its operation verified prior to the test and evaluation of optical sensor systems. Configuration must be based on the experimental test objectives which flow down from the sensor's ultimate mission requirements. In a NICS sensor simulation, the simulator hardware (NICS and NODDS) must be configured, the FPA and its dewar prepared, the drive, data capture, and signal processor electronics properly configured, and the radiation source or sources must be aligned and characterized.

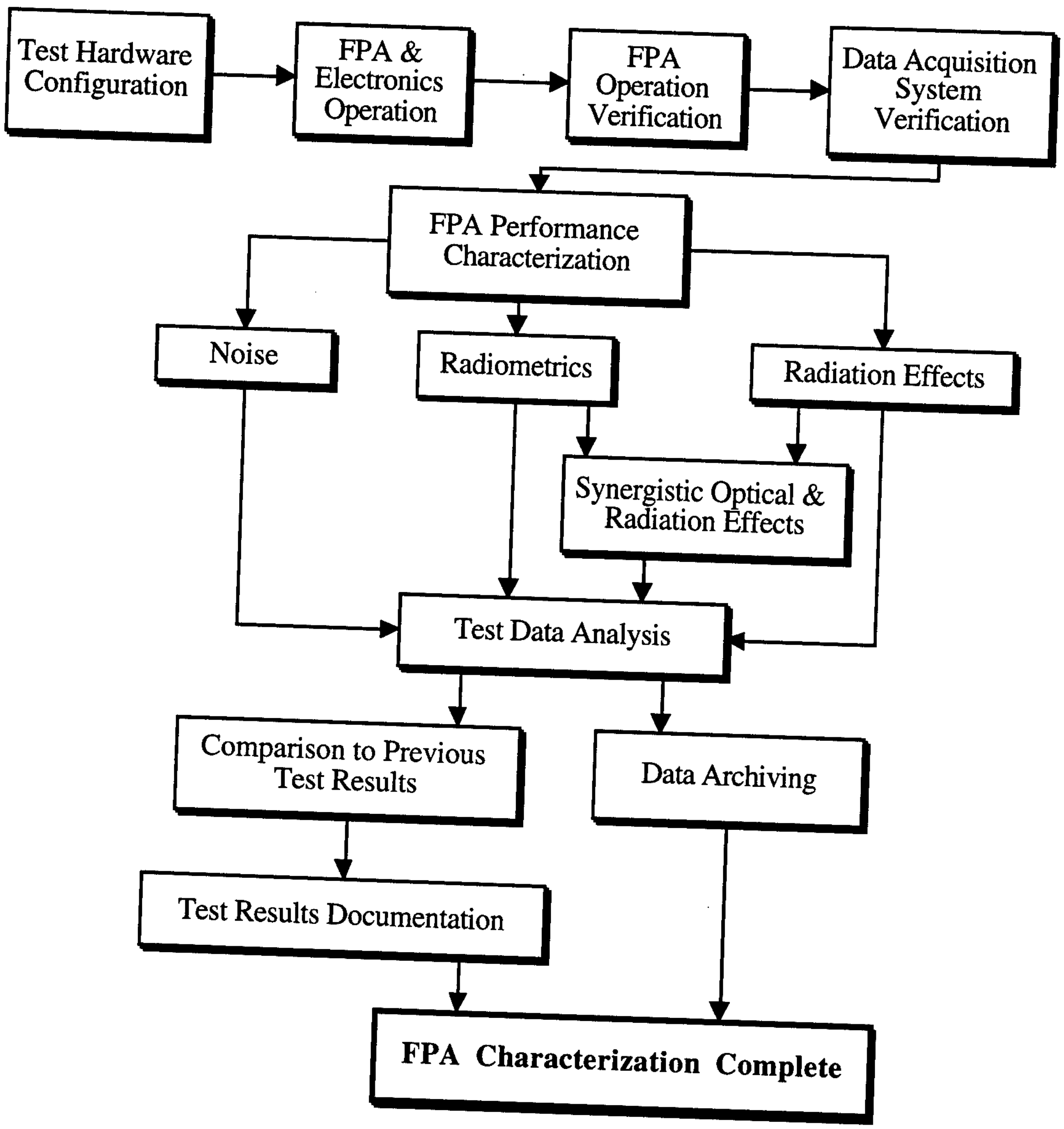

Figure 2-1. Flow chart for FPA characterization testing campaign.

2.1.1 NICS/NODDS Test Hardware Configuration.

All environmental simulator experimental parameters must be derived from the test campaign objectives which should flow down from the sensor mission operational requirements. Since the NICS is an optical scene simulator, most of its operating parameters directly influence the optical signal incident on the FPA under test. The NICS blackbody and its optical density filters in the filter wheel provide flood illumination onto the FPA in order to characterize attributes such as signal linearity, responsivity (signal versus optical flux), output noise as a function of incidence, and bad pixel mapping. Flood radiance and spectrum is controlled by adjusting blackbody temperature. Radiance levels are controlled by optical density filters in the filter wheel. Spectrum and optical density can also be controlled by cold filters located in the FPA test dewar filter cup. Overall background levels are determined by the spectral and optical density cold filters as well as the operating temperature of the NICS optics.

Simulated imagery originates from either a static display mask or the NODDS dynamic displays. The static display is a halftone that must be designed and installed in the NICS prior to operation. It is illuminated by the blackbody, with its radiance determined by the blackbody temperature and the filter wheel filters. The NODDS displays provide fully dynamic, addressable, and reconfigurable scenes for the FPA under test. Aside from the selection of spectral or optical density filters that may be installed over a NODDS display, no other modifications inside NICS are necessary to change the scenes projected. Therefore, during a given test campaign, new scenes can be generated to test effects discovered during the testing campaign without hardware reconfiguration.

There are typically three different sets of imagery that are projected in NICS: optically cluttered structured backgrounds, test patterns (including floods), and target images. Optical clutter either is the result of the natural sensor operating environment, such as earthlimb or auroras, or from man-made battlefield effects, such as nuclear or non-nuclear weapons. Input parameters for the determination of optical clutter scenes include its optical spectrum, physical size, mean radiance and deviation about the mean, scene dynamics, and spatial structure. For statistical scenes such as nuclear clutter, outer scale (another measure of correlation length), functional standard deviation, cutoff frequency, periodicity, and homogeneity are all inputs for scene determination. Clutter imagery must be carefully selected in order to properly stress the signal processing algorithms under test in the simulation.

Target scenarios vary from single and multiple point sources for stand-off surveillance sensors to blooming sources and highly detailed images for interceptor acquisition, tracking, aimpoint selection, and end-game simulations. Testing parameters such as target display frame rate, number of frames, radiance, spectrum, and dynamics must all be considered in addition to the actual content of the frames imaged onto the FPA and signal processors.

Test patterns can vary from flood (flat field) illumination to structured patterns such as gray scales, Air Force bar patterns, crosshairs, and various distributions of pinhole point sources. Test patterns such as bars and crosshairs are particularly useful for aligning and focusing the optical system prior to data acquisition.

Many of the testing parameters that an experimenter must choose for the NICS and NODDS environments simulator are shown in Figure 2-2.

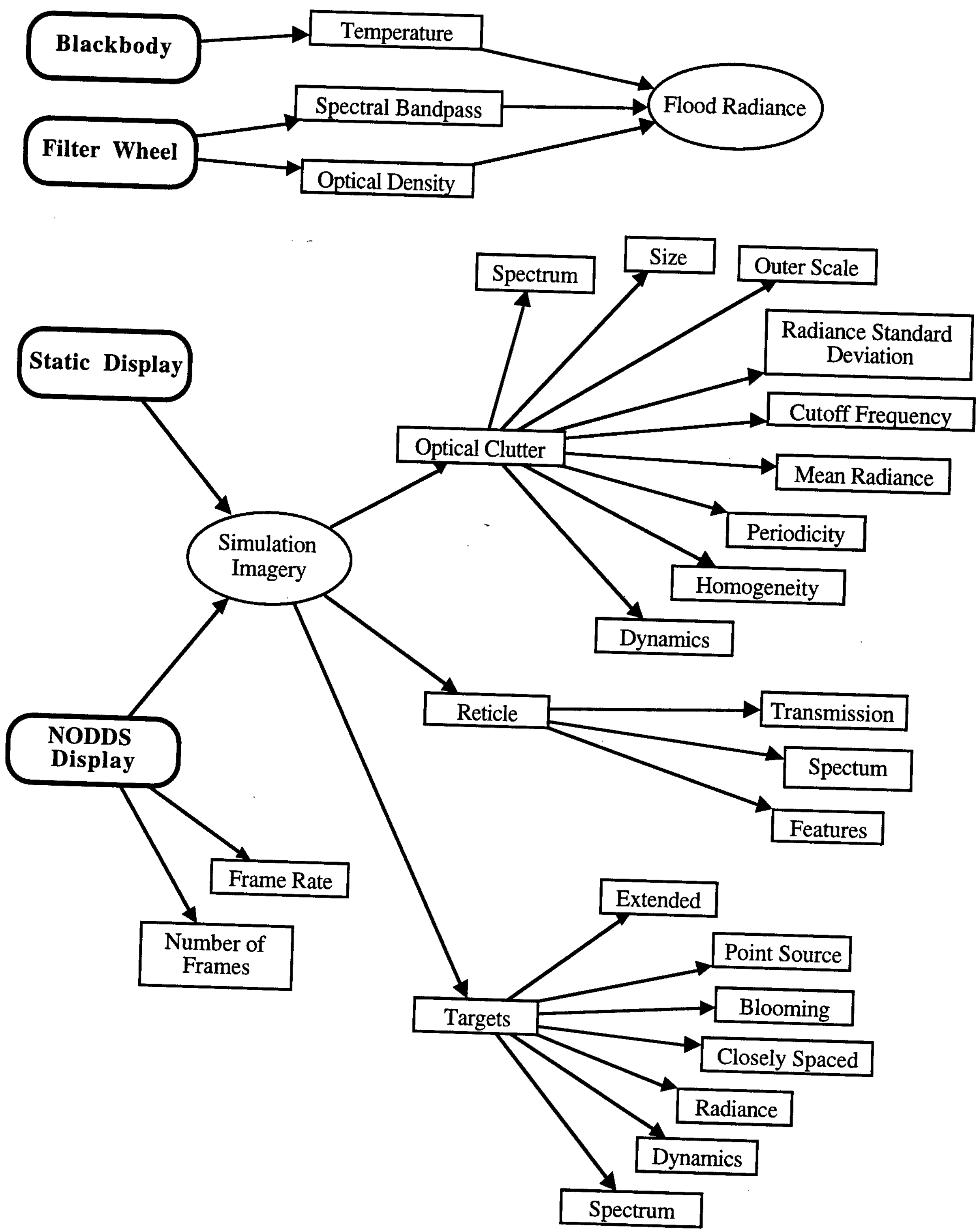

Figure 2-2. NICS and NODDS simulator configuration options.

The NICS Static Display Optical Bench has been previously characterized with many of its attributes and capabilities documented (Pritchett, 1994). Likewise, the NODDS 128 x 128 display characterization has also been documented (Old, 1994). The new NICS Dynamic Display Optical Bench will be characterization will be completed by June, 1995.

2.1.2 Radiation Source Configuration.

Sensor missions may require the sensor to operate in an ionizing radiation environment. If this is the case, radiation sources must be selected and configured in order to accurately simulate these environments the fielded sensor is likely to encounter. Examples of sensor environments that contain radiation include Van Allen belt earth orbits for space-based surveillance and tracking sensors and battlefields containing detonated nuclear weapons for interceptors.

Typical sources that may be used in a combined effects simulation include gamma emitters such as cesium 137 or cobalt 60, Brehmstrahlung sources that emit electrons or x-rays, nuclear reactors emitting neutrons, and various other sources of heavy particles such as protons and heavy ions. Radiation source configuration issues include replicating mission-required dose rates and total dose levels at the components under test, shielding subsystems that do not require irradiation, and synchronizing exposure to other simulator events as well as to data acquisition. Dosimetry at the subsystems being exposed insures proper doses and dose rates necessary for the simulated sensor operating environment.

Radiation environments experimental configuration options are shown in Figure 2-3.

2.1.3 FPA and Electronics Configuration.

Prior to collecting data for a sensor simulation, the sensor FPA must be configured, brought to operation, and optimized to achieve its peak performance. The equipment necessary to operate an FPA includes the device itself, the test dewar, cabling, bias electronics, clock generation electronics, and a data acquisition system.

Test dewar configuration includes installation of the proper motherboard/daughterboard device interface, filtering capacitors and line protection devices, optical spectral and neutral density filters, light baffles and cold stops, and cryogenic cold straps to insure isothermal operation.

FPA clock and bias drive electronics are configured according to FPA device manufacturer's specifications for voltage and current levels, signal line impedance matching, and signal timing. If a FPA readout test device is available, electronics optimization should use it instead of the

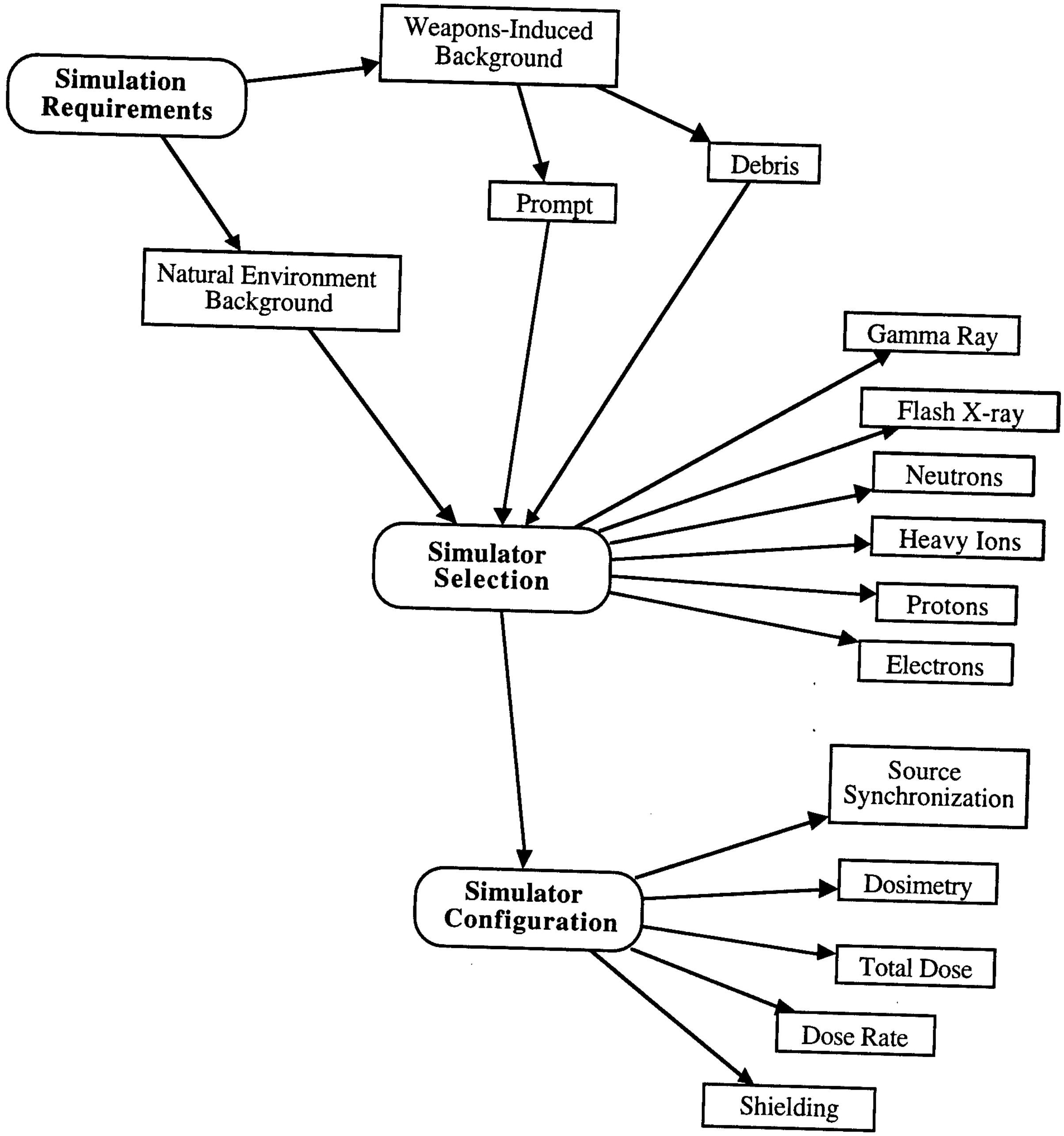

Figure 2-3. Radiation environment configuration options.

hybridized array, because the test device is much less expensive than the readout and detector array hybrid. Once the drive electronics are optimized with the readout, the hybrid FPA can be installed and its electronic and radiometric performance optimized. Optimization frequently requires iterative adjustments of clock timing, rail voltages, and detector and circuit bias levels to achieve peak optical and noise performance.

During FPA performance optimization, the data acquisition electronics should also be adjusted and their performance verified. Parameters such as samples per acquired frame, acquisition system noise levels, frame synchronization, and frame jitter mitigation must all be optimized to insure accurate FPA device characterization. It is necessary to have the data acquisition system running to verify FPA operation. This can make isolating problems in the integrated system difficult at times, particularly when synergistic effects are suspected. If necessary, the data acquisition system performance can be adjusted using calibrated function generators to optimize its performance independent of the FPA.

Major FPA and its associated electronics configuration steps are shown in Figure 2-4.

2.2 SENSOR PERFORMANCE CHARACTERIZATION PROCEDURES.

2.2.1 Noise Performance.

Noise data sets should be acquired for two purposes: to insure that the test system is functioning properly, and to characterize the FPA and its electronics under test. Nominally, during the experiment configuration steps, the test system noise levels have been reduced to the greatest extent possible. Data sets with no illumination should be collected for each integration time and for each setting of other FPA parameters that will be changing during the experiment. Sets should be collected for the FPA running nominally and for the FPA running without the high speed (noisy) output clocks, to determine clock feed-through noise. As many frames as feasible should be collected in order for noise statistics (such as mean levels, standard deviation, and frequency content) to be calculated.

Dark noise data sets should be collected at the start of each testing day and after each experiment reconfiguration in order to verify that all data sets collected during a test campaign have similar noise characteristics.

2.2.2 Radiometric Performance.

FPA radiometric performance is typically determined by evaluating data sets captured during flood illumination. Irradiance data at multiple flood levels yields FPA linearity, responsivity, detectivity, spatial uniformity, dynamic range, as well as other operating characteristics. Radiometric data sets should be collected at several blackbody temperatures to verify simulator radiometrics. Multiple flood levels at each temperature should be collected using the optical density filters in the NICS blackbody filter wheel. Signal levels should range from the background noise floor through hard

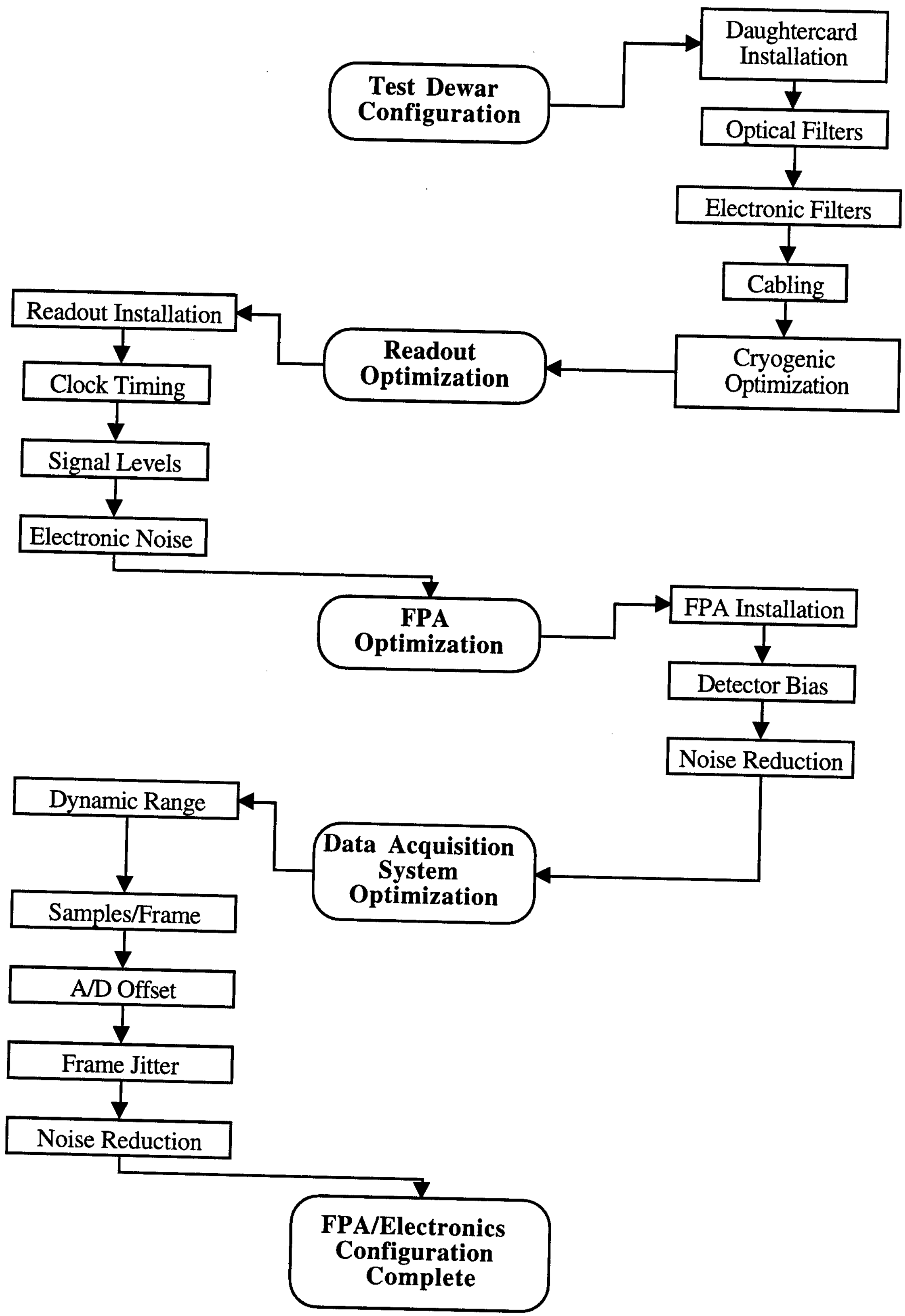

Figure 2-4. Focal plane array and associated electronics configuration options.

saturation. As in the noise data case, flood levels should be collected at as many levels with as many frames per level as is feasible to insure statistically robust results.

In addition to a comprehensive flood data set collected during the campaign, additional flood data sets should be collected at the start of each testing day in order to verify that FPA operating characteristics do not change during the course of a testing campaign. It is usually sufficient to collect a few flood levels at one blackbody temperature for the daily verification sets.

2.2.3 Ionizing Radiation Effects.

Ionizing radiation effects can range from negligible to severe, based on the radiation dose rates, total dose, type of radiation, and the system under test's hardness level. Since performance degradation is the primary effect radiation has on a sensor system, the sensor experiment should attempt to determine the level of degradation as a function of dose rate or total dose. For example, a signal processing algorithm may be affected by impulse noise generated by gamma rays incident on a FPA under test. A frequent effect is that gammas cause the signal processor false alarm rate to increase and the probability of detection to decrease. For prompt radiation events, responses such as lost data frames or lost frame synchronization may occur.

In order to characterize radiation-induced effects of this nature, a sufficiently large data set must be acquired with dose rates varying from no radiation (benign conditions) to a maximum level as determined by the mission requirements. Systems effects can be plotted versus impulse noise event rate to measure the sensor's performance in this environment. As in the noise and radiometric cases, radiation data sets should be acquired for each FPA integration time and parameter configuration to insure a comprehensive characterization. Radiation source dosimetry should be measured for each exposure in order to document both dose rate and total accumulated dose as the experiment proceeds.

2.2.4 Combined Optical and Radiation Effects.

After radiometric and radiation data is collected, it is frequently instructive to acquire simple flood data sets with ionizing radiation in order to investigate potential synergistic effects between the two stimuli. Data should be acquired at several optical and radiation levels in order to better characterize any effects that may be observed.

2.2.5 Optical Sensor Simulation Test Scenarios.

After the optical sensor noise, radiometric, and radiation effects performance are characterized, the sensor can be tested for target acquisition (and tracking) against a variety of simulated environment conditions. Typically it is advantageous to begin evaluating sensor performance against simple scenarios and proceed to more complex scenarios. The target size, shape, emission spectrum, radiance, signal-to-clutter ratio, and dynamics will all be determined by the sensor's mission requirements. Many diverse target as well as scene generation requirements can be simulated using the NODDS dynamic displays.

Figure 2-5 shows a typical progression of testing complexity for sensor target acquisition evaluation. Testing should begin with simple static targets at various radiance levels against no optical background. In progressing to dynamic targets, target trajectory should include motion along the FPA row, column, and along diagonals to check for signal "flicker" as a function of FPA pixel fill factor. The number of targets and spacing between targets is driven by mission requirements. Closely-spaced objects should also be checked for "flicker" as they move across the sensor's field of view.

Once target data is collected, optical clutter can be added as backgrounds. Clutter complexity should progress from little structure (low spatial frequency content) to highly structured (high spatial frequency content). Examples of these include diffuse sources such as an interceptor looking up to a more complex scene including auroras, clouds, or nuclear weapons-induced optical signatures.

For comprehensive combined optical and radiation effects evaluation, ionizing radiation should be added. The combination of dynamic targets, dynamic clutter, prompt radiation, and debris ionizing radiation represent the most stressing scenario that an optical sensor is likely to encounter. Various combinations of clutter, radiation, and targets can be used as necessary to evaluate sensor performance in mission-required engagement scenarios.

2.2.6 Data Evaluation during Test Campaign.

It is imperative that data collected during each step of a sensor testing campaign be evaluated at a rudimentary level during the experiment. The level of analysis complexity should be sufficient to verify data validity and that the data is adequate for further analysis after the completion of the experiment. This near "real time" quick-look analysis significantly decreases the probability that an experiment will be completed and yield no valuable data. The quick-look analysis can ultimately save significant testing dollars if it prevents an experiment from being completed prior to the acquisition of good data to meet sensor evaluation criteria.

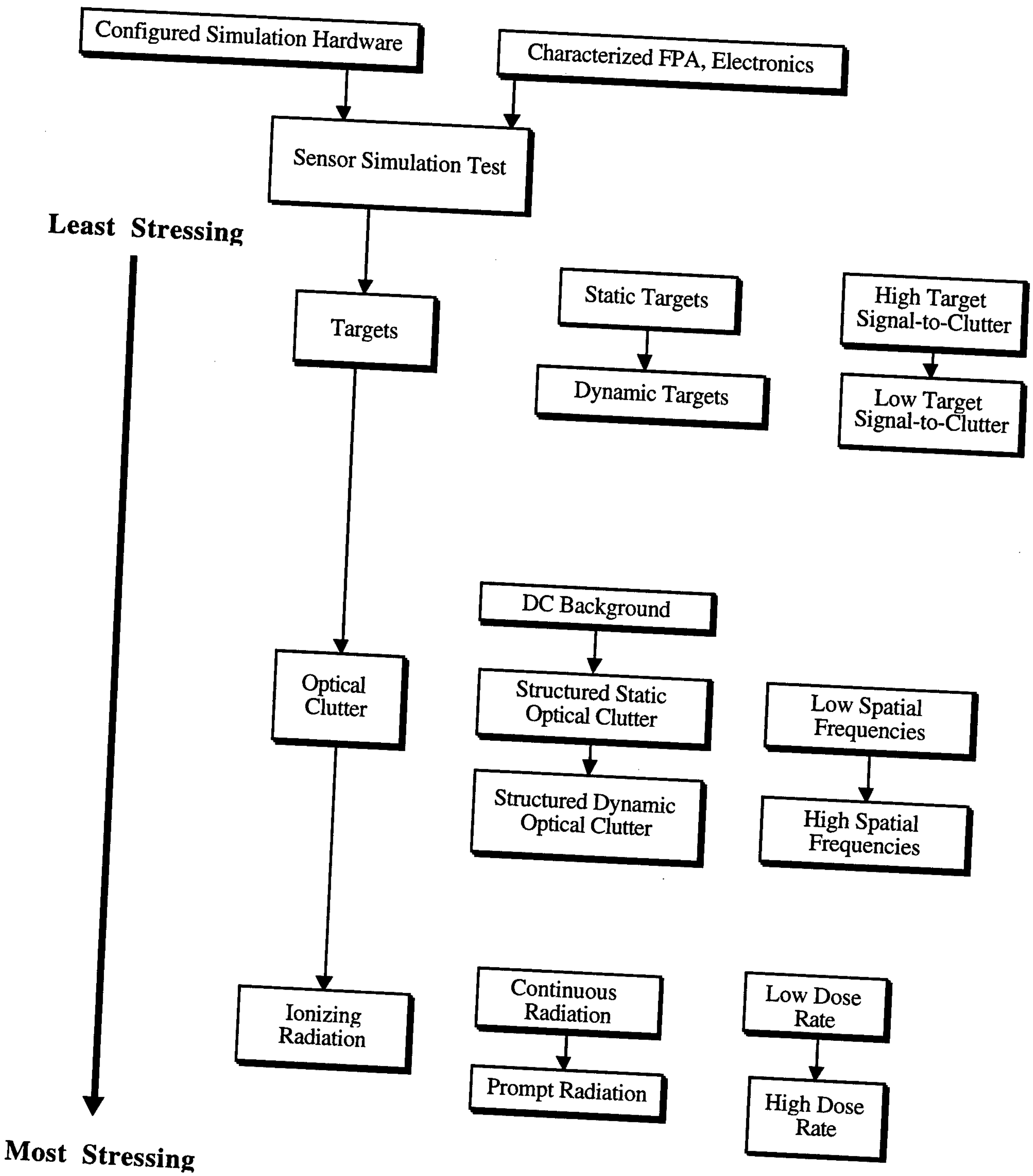

Figure 2-5. NICS sensor testing options.

Typical parameters that should be continually evaluated during an experimental campaign include FPA radiometrics, noise floor levels, optical flux saturation level, data frame synchronization and jitter, and subsystem acquired total radiation dose.

2.3 POST-TEST CAMPAIGN PROCEDURES.

2.3.1 Detailed Data Analysis.

A detailed analysis of the test data should commence after the conclusion of the sensor test campaign. This analysis should yield FPA characterization information such as radiometric responsivity and spatial response uniformity, mean detectivity, D*, dynamic range, noise floor levels, and operability. Sensor signal processor subsystem parameters such as false alarm rate, probability of detection, tracking accuracy, aimpoint selection accuracy, and clutter mitigation performance can be determined. If radiation was an environmental component in the testing, the FPA and signal processor effects of prompt pulse, steady state flux, and total dose can be determined.

2.3.2 Comparison to Prior Test Results.

If test results from a different testing facility are available for the sensor under test, it is frequently valuable to compare the current results to those obtained previously. Prior test results that corroborate the current results are a good indication that the sensor subsystems were operated correctly and that the results obtained in each test are most likely valid. If, however, the results of one test campaign contradict or do not agree with those of another test, then questions arise as to whether there was a similar hardware configuration in the tests, whether the test conditions were the same, and whether there was some component failure or unknown change between the tests. In this event, thorough test documentation may provide the analyst with the reasons for the dissimilar test results.

2.3.3 Test Result Documentation.

The test campaign documentation should provide a complete summary of the test objectives, the procedures followed to meet those objectives, a comprehensive listing of the data acquired during the campaign, the experimental configuration for each data set, data analysis results and conclusions, and recommendations for future testing of the same, or similar, sensor focal planes or electronics. Table 2-1 lists many of the generic entries necessary for a comprehensive experiment report.

Table 2-1. Contents of a experimental test report.

Introduction
Experiment objectives
Test plan listing
Hardware configuration notes
Experiment layout diagram
Daily experimental note log
Summary of test data file headers
Sample image files printed
Radiation dosimetry notes
Radiometric calibration notes
Quick-look data analysis results
Detailed data analysis results
Comparison to previous results

2.3.4 Test Data Cataloging and Archiving.

Experiment documentation should enable a person not associated with the test to understand what data was collected during a test campaign. All data collected during a FPA testing campaign should be archived along with as much information on the testing environment and hardware conditions as possible. Test condition information stored in each data file header provides a certain means for documenting each data set collected. Table 2-2 shows typical NICS Static Display Optical Bench system configuration data that is acquired for each data set collected during a sensor testing campaign. The Dynamic Display Optical Bench will have a similar configuration data set.

Table 2-2. NICS Static Display Optical Bench system configuration data.

Data file path name (DOS)	Beam combiner temp (K)	Tank temp (K)
Triggered DAQ (y/n)	Cold cover temp (K)	Collimator box temp (K)
Trigger offset (s)	Rad shield temp (K)	Scene mask mount temp (K)
Background start (cm)	Cryogen level (% full)	Scene BB mount temp (K)
Background stop (cm)	Target blackbody temp (K)	Scene filter wheel temp (K)
Background rate (cm/s)	OB right temp (K)	Target filter wheel temp (K)
Target X start (cm)	OB center temp (K)	Target mask mount temp (K)
Target X stop (cm)	OB left temp (K)	Target BB mount temp (K)
Target Y start (cm)	Chamber vacuum (μTorr)	Scanner mount temp (K)
Target Y stop (cm)	Scene blackbody temp (K)	Imager box temp (K)
Target rate (cm/s)		

Table 2-3 shows typical FPA and data acquisition system test configuration information that should be stored with each data set collected during an FPA testing campaign.

Table 2-3. FPA and data acquisition test configuration data.

Device manufacturer	Experiment Number	TB #2 Sample period
Device nomenclature	Total dose on device	TB #1 Sample period
Description of test	Gamma flux level	Samples in TB2
Radiation facility / source type	Detector bias level	Samples in TB1
Detector number(s)	Voltage amp gain setting	Number of post trigger samples
Blackbody chopping frequency	Blackbody temperature	Number of pretrigger samples
TIA gain setting	Integration time	Preamp Channel 1

Table 2-3. FPA and data acquisition test configuration data (continued).

TIA LF roll-on	Timing file name	Preamp Channel 2
TIA HF roll-off	Date	Preamp Channel 3
TIA coupling	Time	Preamp Channel 4
Voltage amplifier LF roll-on	Device Temperature	Data Acq. Trigger coupling
Voltage amplifier HF roll-off	Active segment number	Data Acq. Trigger
Voltage amplifier coupling	Acquisition mode	Data Acq. Trigger slope
Blackbody aperture size	Number of channels recorded	Data Acq. Upper trigger level
Optics F/#	Channel to trigger on	Data Acq. Lower trigger level
LN2 filter	Operator name	External trigger setup
LN2 aperture	Data directory path	Detector length (physical, optical)
Distance LN2 aperture to device	Recorder status	Detector width (physical, optical)
LHe filter	Segment size	Detector thickness
LHe aperture	Starting segment number	
Distance LHe aperture to device	Ending segment number	
Dewar Background Incidence	Data Format bytes/pixel	

All data acquired during a test campaign should be archived using long lifetime media such as a SyQuest or Bernoulli cartridge or more preferably a permanent write-once, read-many compact disc (WORM CD). The data format on the media should be accessible to as many data processing platforms as possible. A good choice for data format is the ISO 9000 standard for CD media, since many platforms, including personal computers and workstations, have access to the standard.

SECTION 3
TEST PLAN FOR SENSOR TEST AND EVALUATION

3.1 SAMPLE SENSOR TEST PLAN.

The following is a sample test plan developed for an experiment designed to evaluate an LWIR staring focal plane array in the NICS at the MRC Radiation Test Laboratory. The sensor FPA was evaluated at a single integration time and device bias with two different timing patterns, referred to as gamma circumvention "on" and "off". The testing focused on FPA noise and radiometric characterization as well as its performance in both prompt x-ray and debris gamma ionizing radiation environments. Sensor simulations included target imagery in benign, optically cluttered, and radiation cluttered backgrounds.

3.1.1 Flood Datasets.

1. Set integration time based on scene blackbody (BB) floods.
2. Set blackbody temperature.
3. Turn gamma suppression off and capture 45 frames.
4. Turn gamma suppression on and capture 45 frames.
5. At several temps, capture OD's for BB temperature check.
6. Repeat 3, 4 and 5 at $\approx$ 10 BB temps (dark - 660K). Signal levels range from no optical signal/background into hard FPA saturation.

3.1.2 Gamma Datasets.

1. Capture gamma set (90 frames) at 1.5×10^9 γ/cm^2s with gamma suppression on.
2. Repeat for gamma suppression off.
3. Reduce gamma flux to 7.5×10^8 γ/cm^2s and capture 90 frames.

3.1.3 Floods and Gammas Datasets.

1. Set flood level for near saturation signal level. Verify that FPA is not saturated.

2. Capture gamma and flood (30 frames) at maximum gamma flux rate (1.5 x10^9 γ/cm^2s) with gamma suppression on.

3. Capture 30 frames with flood only.

4. Capture 30 frames of gammas with gamma suppression off.

5. Capture 30 frames with flood only.

6. Repeat 2-5 using 10% transmission filter over flood.

7. Repeat 2-5 using 3.6% transmission filter over flood.

8. Repeat 2-7 with gamma flux rate of 5x10^8 γ/cm^2s.

3.1.4 Targets and Gamma Datasets.

1. Set targets for signal level ≈ 2 x single gamma event. Verify that FPA is not saturated.

2. Capture target and gamma set (30 frames) at maximum gamma flux rate (1.5E9 ph/cm2s) with gamma suppression on.

3. Repeat step 2 for gamma suppression off.

4. Repeat 2 and 3 using 50% transmission filter over targets (target ≈ single event).

5. Repeat 2 and 3 using 10% transmission filter over target (target ≈ 20% of single event).

3.1.5 Stationary Clutter, Moving Targets, and Gamma Datasets.

1. Set clutter for signal level ≈ 50% FPA saturation. Verify that FPA is not saturated.

2. Set targets for signal level ≈ 20% single gamma event (10% filter from above).

3. Capture dataset (30 frames) at maximum gamma flux rate (1.5E9 γ/cm2s) with gamma suppression on. Document target location.

4. Capture dataset (30 frames) for gamma suppression off at same target location.

5. Step target complex about 1/2 pixel along diagonal trajectory.

6. Repeat 3 and 4.

7. Repeat steps 5, 3, and 4 for 10 datasets.

3.1.6 Moving Clutter, Moving Targets, and Gammas Datasets.

1. Set clutter for signal level ≈ 50% FPA saturation. Verify that FPA is not saturated.
2. Set targets for signal level ≈ 20% single gamma event.
3. Capture dataset (30 frames) at maximum gamma flux rate (1.5E9 γ/cm2s) with gamma suppression on. Document target location.
4. Capture dataset (30 frames) for gamma suppression off at same target location.
5. Step target complex about 1/2 pixel along diagonal trajectory.
6. Move clutter x pixels in vertical.
7. Repeat steps 3-6 for 10 datasets.

3.1.7 FPA Temporal Response Using NODDS Array.

1. Image NODDS emitter blinking at 40 Hz onto FPA.
2. Capture 100 frames with gamma suppression on.
3. Repeat data capture for gamma suppression off.
4. Repeat steps 2 and 3 for NODDS running at 20 Hz and 10 Hz.

3.1.8 Flash X-ray Datasets.

Note: Flash X-ray (FXR) voltages refer to single Marx bank voltage. Total shot voltage is 12 times the stated voltage.

1. Capture FXR set (90 frames) with no optical signal at 90 KV charge with gamma suppression on.
2. Repeat for gamma suppression off.
3. Repeat steps 1 and 2 for 80 KV and 70 KV charge.

3.1.9 Floods and FXR Datasets.

1. Set flood level for near saturation signal level. Verify that FPA is not saturated.
2. Capture FXR and flood (90 frames) at 90 KV charge with gamma suppression on.
3. Capture 90 frames with flood only.
4. Capture 90 frames of 90 KV charge shot with gamma suppression off.
5. Capture 90 frames with flood only.
6. Repeat 2-5 using 10% transmission filter over flood.
7. Repeat 2-5 using 3.6% transmission filter over flood.
8. Repeat 2-7 with 80 KV charge on FXR banks.

3.1.10 Stationary Clutter, Moving Targets, FXR, and Gamma Datasets.

1. Set clutter for signal level ≈ 50% FPA saturation. Verify that FPA is not saturated.
2. Set targets for signal level ≈ 20% single gamma event (10% filter from above).
3. Set target stage for 3 cm diagonal trajectory at 1 cm/sec with frame sync trigger 1 second into scan.
4. Capture dataset (90 frames) at maximum gamma flux rate (1.5E9 γ/cm2s) with gamma suppression on with 90 KV FXR shot synchronized to start of scan. Document target location at start and end of scan.
5. Repeat step 4 for gamma suppression off for same target scan.
6. Step target complex about 1/2 pixel along vertical trajectory.
7. Repeat steps 4 and 5.

SECTION 4
DISTRIBUTED INTERACTIVE SIMULATION METHODS APPLIED TO NICS TESTING

4.1 OVERVIEW OF NICS DISTRIBUTED INTERACTIVE SIMULATIONS.

Distributed Interactive Simulation (DIS) testing using the DNA NICS with NODDS dynamic displays represents a new means of providing DNA sensor test and evaluation capabilities to sensor testing customers. The implementation of DIS methods to NICS sensor simulations offers many advantages to testing customers: rapid distribution of testing data and results to multiple sensor designers, developers, and program offices; widespread availability of the DNA sensor test and evaluation capabilities; reduced costs for the testing customers resulting in more efficient, higher quality sensor system demonstration and validation; and increased visibility for DNA programs and technology development efforts. By utilizing a distributed data communications network, the test data is made available to multiple sites and/or program offices, providing wider area distribution of test results.

4.2 ADVANTAGES OF NICS DIS TESTING.

Widespread, high speed data distribution adds significant value to the NICS/NODDS sensor testing facility. The major attributes of using distributed interactive networking include real-time scene generation from remote sites and hardware-in-the-loop test capabilities, data validation in near real time to insure experiment validity, and reduced testing costs for all programs involved in the simulation.

4.2.1 Hardware-in-the-Loop NICS Testing.

High speed data communications linking the NICS simulator to remote scene generation and data processing facilities provides an integrated, multi-facility hardware-in-the-loop simulation capability. Simulation scenes generated by remote computing facilities can be relayed over high bandwidth communications links such as T1 lines to the NICS facility. There, the scenes will be processed for display on the NODDS and projected through the NICS optics onto the sensor FPA under test. Data is acquired, formatted and encrypted using the proper protocols for the communications service, and sent out to the remote processing facility. The signal processing facility computes sensor maneuvers and diverts according to the scenery input, calculates new sensor state vectors, and sends the state vectors to the scene computation system. The new scene is computed, formatted for transmission, and sent to the NICS facility for display. This distributed system makes use of multiple facilities' remote resources in a single, integrated, hardware-in-the-loop sensor simulation. A simple conceptual layout of a distributed NICS sensor simulation is shown in Figure 4-1.

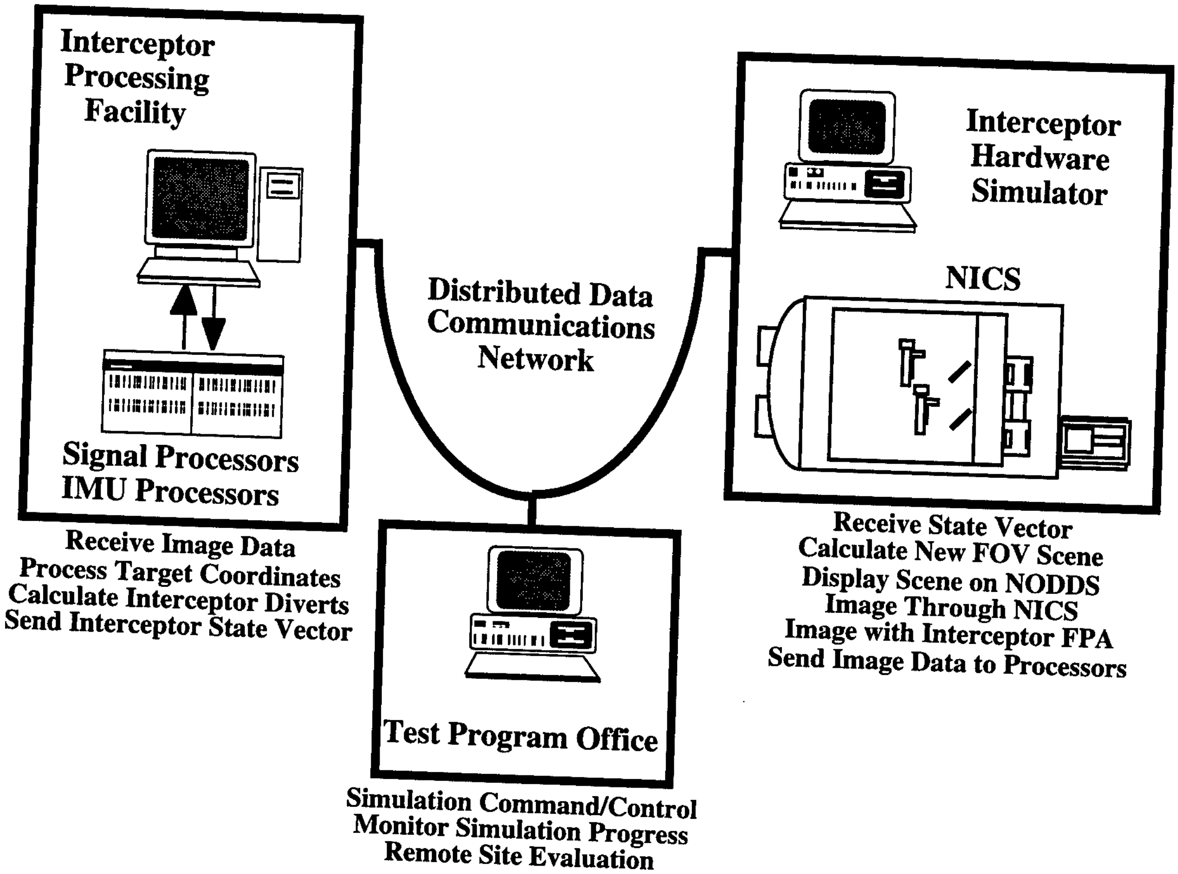

Figure 4-1. Distributed NICS sensor simulation linking separate facilities resources over high bandwidth communications network.

4.2.2 Data Validation During the Test Campaign.

Since sensor data can be evaluated in near real time by multiple analysts, DIS testing can prevent the need for additional test campaigns when corrupt or simply insufficient data sets are acquired during a test. Results will quickly indicate if the test objectives are being met with the acquired data. This prevents the experiment from ending, hardware being disassembled, and personnel leaving the test site without the required data. DIS prevents a premature experiment shutdown and consequently reduces the costs of experiment reconfiguration and retesting. In addition, multiple analysts processing data can help diagnose problems during initial hardware configuration at the beginning of a test campaign.

4.2.3 DIS Reduces Testing Costs.

DIS usage in NICS testing lowers the total costs of performing sensor subsystem testing and evaluation. Cost reductions could mean the difference between performing an actual test and relying on sensor software simulations, which in many instances do not faithfully replicate the sensor operating environment. The most significant cost savings (aside from saving a retest due to insufficient data collection) are in personnel travel and in hardware shipment. Table 4-1 lists several areas of cost savings using DIS.

Table 4-1. Estimated cost savings for a nominal two week NICS test using DIS.

NICS Testing Savings with DIS	Test Savings
Disassembly and packing at MRC	$1K
System assembly/checkout at remote facility	$2K
System disassembly at remote facility	$1K
System assembly/checkout at MRC	$1K
ANICS personnel travel	$3K
Customer analyst travel	$12K
NICS shipment with commercial carrier	$8K
Remote facility coordination & planning	$1K
Remote site/shipping contingencies	$1K
Radiation source operation	$10K
Total Savings for Test Customer	**$40K**

Customer technical staff travel savings can be significant. DIS will allow multiple data analysts at various contractor and program office sites to analyze test data in near real time without travel or equipment shipment costs. Assuming that four analysts will study the test data over the course of a two week test conducted at the MRC Radiation Laboratory, the customer would save roughly $12K. The total test savings is about $40K based on these assumptions.

For a NICS/NODDS DIS FPA test, the most that a customer would ship would be their focal plane, test dewar, and possibly their data acquisition electronics. The shipment of these items is less risky, involves less labor to setup, and in general is much less expensive than the shipment of the NICS and its support systems. The reduced risk to hardware resulting from less frequent disassembly and shipment results in long term cost savings in maintenance and operation of the NICS/NODDS systems.

4.3 DIS METHODS APPLIED TO NICS SENSOR TESTING.

A NICS sensor simulation utilizing DIS would have a sensor focal plane array mounted in the NICS system either at MRC, a government testing facility, or at a program office subcontractor's facility. NODDS dynamic emitter arrays would provide the optical scene and targets for the sensor and the testing facility would provide the ionizing radiation environment, if required. Test campaign data sets containing the combined optical and radiation effects would be acquired by either the NICS or the customer's data acquisition hardware. The acquired data would then be properly formatted into transmission protocols, encrypted if necessary, and transmitted over a high bandwidth carrier for sensor signal processing and evaluation at a remote site or sites.

Following signal processing, commands for changes in the scene, targets, and/or radiation environment could be transmitted to provide a near real time "hardware in the loop" evaluation of the sensor signal processing operability. This capability is particularly valuable for interceptor testing, since scenarios with acquisition, tracking, and endgame kills can be simulated for various optical and radiation environments using testing resources from different facilities located around the country.

4.4 DATA COMMUNICATION AND NETWORKING ISSUES.

A distributed simulation sensor test can make use of a wide variety of data distribution methods and communications. Low speed options such as 28.8 kb/s commercial modems using data compression over analog phone lines can achieve about 40 kb/s transfer rates. Digital services such as Switched 56 and ISDN provide 56 kb/s transfer rates which, when using data compression, can achieve over 100 kb/s transfer rates. Higher speed services such as frame relay, T1, and T3 offer much higher bandwidth but at significantly higher cost. Bandwidth usage must be considered in the context of testing requirements and available testing budgets.

Table 4-2 lists several communications services, available bandwidths, and rough-order-of-magnitude costs. The cost per unit bandwidth of these services is likely to decrease significantly in the future.

Table 4-2. Candidate data communication services for DIS NICS sensor testing.

Service	Service Bandwidth	Transmission Bandwidth	Installation Cost	Service Cost	Hardware Required
Standard Telephone	56 kb/s analog	115 kb/s with compression	$100	$25/month + connect time	$600 for 2 modems
ISDN	56 kb/s digital	115 kb/s with compression	$50	$42/month + connect time	$5000 for 2 routers, adapter
Switched 56	56 kb/s digital	115 kb/s with compression	$50	$42/month + connect time	$3000 for 2 routers
T1	1.544 Mb/s digital	> 3 Mb/s with compression	$0	$13K/month	DSU/CSU, routers
Switched T1	1.544 Mb/s digital on demand; dial up service	> 3 Mb/s with compression	$0	$1500/month plus $400/ hour usage	DSU/CSU, routers

As an example, a typical 256 x 256 FPA will have data captured as 12 to 16 bit, and stored as 2 byte integers. At 100 kb/s, this represents a frame being transmitted every 10.5 seconds. Depending on the data content, careful selection and implementation of data compression protocols often enable the frame transmission rate to at least double. Therefore, DIS methods applied to NICS sensor simulations can greatly enhance test campaigns for a small incremental increase in the testing budget.

4.5 MRC RADIATION LABORATORY IN DIS NICS TESTING.

The MRC Radiation Test Facility contains a radiation bunker built specifically to house the NICS for combined effects radiation testing. The bunker also contains the cable runs, electrical power, and dosimetry necessary to perform combined optical and ionizing radiation effects testing of sensor focal planes and related electronics. Therefore, little or no reconfiguration is required to support customer testing in this facility. Continuous gamma environments are provided by the

1150 Ci ^{137}Cs source, which provides an incident gamma flux of 1.5 x 10^9 γ / cm^2sec at a sensor focal plane in NICS. In addition to the gamma source, the MRC Pulserad 112A Brehmsstrahlung (FXR) machine simulates prompt ionizing radiation pulses on a sensor under test. The pulse generator is capable of 1.8 MeV, 30 nsec pulses that provide dose rates of 5 x 10^{10} γ / cm^2sec at the face plate. Delivered dose rates inside the NICS are estimated to be on the order of 1 x 10^9 γ / cm^2sec. If customer testing requirements are at or below these dose rates, then testing at MRC instead of at alternative radiation facilities can save thousands of dollars per test in facility and shipping charges.

SECTION 5
CONCLUSION

This test methods interim report documents methods developed for the test and evaluation of interceptor and surveillance sensor systems using the Defense Nuclear Agency (DNA) Nuclear Infrared Clutter Simulator (NICS) system. We have presented configuration requirements for the NICS, NODDS, and sensor FPA under test and provided a general overview of basic requirements for optical sensor test and evaluation. The methods presented here have evolved as the result of experience gained over the course of several NICS sensor focal plane array (FPA) test campaigns and the subsequent data analysis necessary to evaluate FPA and modeled sensor performance.

SECTION 6
REFERENCES

1. Old, T. E., R. Hendrick, D. Moore, D. Pritchett, B. Ludington, K. Erickson, *Nuclear Infrared Clutter Simulator Final Report, Volume 1: NICS Hardware, Electronics, Analysis, and Programics Description; Volume 3: Appendices,* MRC-R-1451, Mission Research Corporation, 1993 (Unclassified).

2. Pritchett, D. G., D. K. Moore, T. E. Old, R. W. Hendrick, "The Nuclear Infrared Clutter Simulator (NICS)," *Journal of Radiation Effects, Research and Engineering*, Vol. 13-1 (Unclassified).

3. Pritchett, D. G., D. K. Moore, T. E. Old, T. Morgan, R. Kidd, K. Erickson, *Characterization of the DNA Nuclear Infrared Clutter Simulator (NICS (U))*, DNA-TR-94-165 (MRC-R-1485), Mission Research Corporation, 1994 (Unclassified).

4. Old, T. E., D. K. Moore, D. G. Pritchett, *Nuclear Optical Scene Display Technology (NODST), Demonstration Display Technical Report,* MRC-R-1476, Mission Research Corporation, 1994 (Unclassified).

5. *Critical Design Review for the NICS Dynamic Display Optical Bench Upgrade*, Mission Research Corporation, November 17, 1994 (Unclassified).

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